Green Building Design

Green building design, also called sustainable design or total building design, is a process in which the design and construction teams work together to produce a building that, not only meets the Owner's time and budget requirements, but is socially and environmentally responsible as well.

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Background

We consume an enormous amount of resources in the construction and operation of buildings. Consider the following facts adapted from the United States Green Building Council publication called Leadership in Energy and Environmental Design Reference Guide Version 2.0[1]:

1. Buildings in the United States Consume more than 30% of the total energy produced and 60% of the total electric energy produced. The majority of this energy is produced from non-renewable resources like oil, coal, natural gas, and uranium (nuclear). Consumption of these resources is a major factor in numerous growing environmental problems including acid rain, greenhouse gases, acid mine drainage, and radioactive waste.

2. Each building occupant uses 20 gallons of potable water each day for consumption and to flush toilets/urinals. Our total water consumption in the United States averages 340-billion gallons each day. We withdraw 3.7-trillion gallons of water from our aquifers each year. This ongoing deficit has lowered the average level of aquifers, in the United States, by 100 feet since 1940.

3. Construction and demolition waste from buildings makes up about 25% of the total solid waste stream in the United States. On average, we generate 2.5 pounds of solid waste for each square foot of floor space we build.

The way in which we go about constructing and operating buildings has an enormous effect on the quality of our environment and the rate at which we use up our shrinking resources. Furthermore, the site selection for these buildings can degrade our communities through increasing urban sprawl and the elimination of valuable farmland, forests, and wetlands. The environmental quality within the buildings can also have an effect on our quality of life. Most of us spend over 90% of our time indoors. Good, healthful indoor environments are essential to our productivity and wellbeing. In summary, we make our buildings and then our buildings make us.

Current Building Design Practice

Despite their enormous effect on our health, productivity, community, and environment, current building design practice tends to degenerate into a philosophy of faster and cheaper is better. To accommodate the demand for fast and cheap buildings, the traditional design approach tends to be a linear one that minimizes the amount of interaction between the engineer, architect, Owner, and contractors.

Once an architect has finished interviewing the Owner and has developed a floor plan and programming information, the engineer calculates loads and fills in the necessary mechanical and electrical systems. After the engineer has finished and issued the construction documents, the contractors turn the documents into a working building. This approach, involving multiple handoffs, is limited and does not address the demands of today's building industry. In a paper titled *Achieving Architectural and Engineering Collaboration in Building Design* (ASHRAE 1995) P. Richard Rittlemann states the following:

> We have entered an era in which a team of generalists and specialists is necessary to competently design modern buildings…this necessary teamwork frequently does not occur…"

In another paper titled *Cooperation + Collaboration + Communication = Total Building Design* (ASHRAE 1995), Richard B. Hayter states buildings should be:

> "…economical in both original investment and operation throughout their lives…the air in these buildings is clean, comfortable, and contributes to the productivity of those occupying that space…the systems that create indoor air are reliable and safe with no adverse impact on the outdoor environment.

Green building design is an integrated, team approach that starts when the architect is conducting initial interviews and continues until the building is constructed to the Owner's satisfaction and has been occupied. Such an approach encourages all the design and construction parties to work in a team environment, looking for ways to cut cost and energy consumption without compromising overall building quality. It is important to provide this service early on, when changes are relatively easy and inexpensive, and will have minimum impact on the project schedule. Green building design provides better buildings than the traditional design approach while greatly enhancing a building's social and environmental value.

United States Green Building Council

In 1993, a group of industrial, environmental, and academic leaders formed the United States Green Building Council (USGBC). Mission of USGBC is to accelerate the adoption of green building design practices, technologies, policies, and standards. USGBC is a non-profit, non-government agency which quickly grew to a membership of over 400 leading international organizations including product manufacturers, environmental leaders, building and design professionals, building owners, and financial industry leaders. Contact information for USGBC is as follows:

United States Green Building Council
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One of the primary functions of USGBC is to establish guidelines on what makes a building green. Those guidelines are published under the Leadership in Energy and Environmental Design (LEED™) program. LEED™ is a registered trademark of the USGBC.

LEED™

In order to design a building that can be certified as a green building under LEED™, several factors/activities must be incorporated into the design. Those factors and activities are listed below:

Sustainable Sites

- Building should not be developed on prime farmland, land located near the 100-year flood plain, land located within 100-feet of a wetland, or on existing public parkland. Building should be developed, preferably, within existing urban areas to preserve green spaces and reduce urban sprawl. Ideally, the building should be developed on cleaned-up and rehabilitated brown-fields.
- Orient the building to reduce heat loss in the winter and heat gain in the summer. Use plantings to block wind and direct sunlight.
- Site disturbance should be kept to a minimum. Buildings with small footprints are preferred. Maintain existing vegetation located more than 40 feet from the building or 5 feet from roadways and walkways. If the site was previously developed, minimize paving and add green areas on the building site.
- Minimize storm water runoff. Provide a means to filter the runoff through plants and settling basins before it is discharged to sewer.
- Reduce outdoor light pollution by specifying shields on outdoor lighting.

Water Efficiency

- Specify natural landscaping that requires little to no artificial irrigation. If irrigation is required, specify drip irrigation.
- Reduce domestic water use by specifying water-conserving toilets, urinals, and showers.
- Capture and use rainwater for irrigation, makeup to cooling towers, and washing cars. If local building codes permit, consider using rainwater to flush toilets.

Energy and Atmosphere

- Have the building commissioned by a designated Commissioning Authority.
- Energy performance of the building must meet or exceed the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90.1[2].
- No chlorofluorocarbon (CFC) containing equipment permitted in the building.
- When practical, use renewable energy resources like solar, wind, and biomass.
- Reduce or eliminate the use of hydro-chlorofluorocarbon (HCFC) containing equipment.
- Provide a means to measure ongoing energy and water consumption.
- When practical, buy electric power from a green power provider (wind farm).

Indoor Environmental Quality

- Building design must comply with ASHRAE Standard 62[3] and ASHRAE Standard 55[4].
- No smoking in the building.
- Carbon dioxide can be monitored to measure ventilation effectiveness.
- Design must insure good ventilation effectiveness.
- Contractor must develop and follow an indoor air quality management plan during construction.
- Specify building materials that emit little to no volatile organic compounds (VOC).
- Indoor chemical pollution sources must be isolated and their emissions exhausted.
- Building occupants should have a high degree of control over their environment including views/daylight from outdoors.

Materials and Resources

- An area in the building must be designated for the storage and collection of recyclables.
- It is preferred to reuse materials from existing buildings.
- Recycle 50 to 75% of the construction waste.
- When practical, specify salvaged material.
- Specify materials with recycled content.
- Specify materials that are located within 500 miles of the site.
- Specify rapidly renewable materials like bamboo, pine, and wheat grass.
- Use only wood grown on tree farms that use certified practices.

Benefits of Green Buildings

The idea that building green can actually improve the financial performance of a building may seem new to some people. However, there is a growing list of successful companies that are consciously using a sustainable approach to business in which environmental and economic concerns reinforce each other. Many of these companies have built green buildings and have received sizable returns on their capital investments. These companies include Patagonia, The Gap, Herman Miller, Interface, Sony, Wal-Mart, Duracell, HBO and S.C. Johnson. The Defense Department, the National Park Service and many local city governments also have adopted green building standards for the long-term economic value these standards add to public buildings. Some of the benefits of green buildings are summarized in the following chart.

Green Building Benefits

(Typical 100,000 Square-Foot Office Building)

Description	Benefit	Notes
Overall Energy Performance	**Annual savings beyond ASHRAE 90.1**	
20% (2 LEED™ Points)	$20,000 to $120,000	1
30% (4 LEED™ Points)	$30,000 to $180,000	1
40% (6 LEED™ Points)	$40,000 to $240,000	1
50% (8 LEED™ Points)	$50,000 to $300,000	1
60% (10 LEED™ Points)	$60,000 to $360,000	1
On-Site Renewable Energy	**Annual savings: On-site generation**	
5% (1 LEED™ Point)	$5,000 to $30,000	1
10% (2 LEED™ Points)	$10,000 to $60,000	1
20% (3 LEED™ Points)	$20,000 to $120,000	1
Human Performance	**Gains from better IEQ**	2
2 to 4% improvement	$590,000 to $1,200,000 a year	3
Learning/comprehension	20 to 26% improvement	4
Classroom attendance	Improve by 1.6 to 1.9%	5
Growth in children	Improve by 0.8 inches a year	5
Retail Sales	**Increase by 31 to 49%**	6
Site Development	**Initial Construction Savings**	
Sustainable Site Design	Save $4,000 to $10,000 per acre	7
Sustainable Site Infrastructure	Save $150,000 to $300,000 per mile	8
Landscaping	**Use Native Planting Material**	
Native Planting	Save $7,500 to $22,500 up front	9
Lawn maintenance	Save $24,000 to $60,000 annually	10
Cooling Equipment	Reduce *equipment* size	11
20%	Save $60,000 up front	12
30%	Save $90,000 up front	12
40%	Save $120,000 up front	12
50%	Save $150,000 up front	12
Water Consumption	Save 1,000,000 *gallons* a year	13
Intangibles		
Marketing	Put your LEED building in your literature	
Community	Your building can be a community asset	
Worker hiring and retention	People prefer to work in green buildings	
Public good will	Your firm can get good publicity	
Leadership	Your firm can be seen as a leader	
Stewardship	Sustainable environment = long-term profit	

Notes:

1) Savings based on a 100,000 square-foot commercial building with annual energy consumption of $1 per square-foot (typical office building) to $6 per square-foot (typical laboratory).

2) IEQ is indoor environmental quality. It includes indoor air quality (temperature, humidity, motion, and cleanliness), natural daylighting strategies, acceptable noise criteria (NC) levels, and views to outdoors.

3) Savings based on 650 people in a facility, each having an average combined salary and benefits of $45,000 per year.

4) Heschong Mahone Group, Daylighting in Schools – An Investigation into the Relationship Between Daylighting and Human Performance, California Board for Energy Efficiency, California.

5) Alberta Education, A Study Into the Effects of Light on Children of Elementary School Age – A Case of Daylight Robbery, 1992, Alberta Education Policy and Planning Branch, Edmonton, Alberta.

6) Heschong Mahone Group, Skylighting and Retail Sales – An Investigation into the Relationship Between Daylighting and Human Performance, California Board for Energy Efficiency, California

7) Savings based on using natural drainage measures, basins, reducing impervious surfaces, and cluster development; Northeastern Illinois Planning Commission – Reducing the Impacts of Urban Runoff with Alternative Site Design Approaches.

8) Savings based on using vegetated drainage swales in lieu of curb and gutter and underground storm sewer system.

9) Five acres planted with native habitat as compared to irrigated turf will save $1,500 to $4,500 per acre.

10) Five acres planted with native habitat as compared to irrigated turf will eliminate $2,000 to $5,000 of lawn care and maintenance per month.

11) Cooling equipment size is reduced in a green building through the use of cool daylighting techniques, higher levels of insulation in the roof and walls, better glazing, and accurate load analysis.

12) Assume a conventional cooling system for a 100,000 square-foot commercial building sized to deliver 250-tons of peak cooling demand (400 square feet per ton) at an installed cost of $300,000 ($1,200 per ton).

13) Assuming 650 building occupants use 20 gallons of water per day in a conventional building and 30% less in a green building.

Green Buildings Save Resources

Resource-conscious design strategies involve reducing a building's consumption of the earth's resources over the entire life of a building. These strategies include efficient land use, energy efficiency, storm water filtration, minimal habitat disruption, native landscaping, water efficiency, waste reduction and selection of building materials with minimal environmental impact.

Healthy design strategies on the other hand, include enhancing all aspects of the interior environment that contribute to making building occupants more healthy and comfortable. These include enhanced indoor air quality, daylight access and quality, thermal comfort, acoustics and a greater connection to the outdoors.

Many building owners are surprised to learn that the cost to design and build a building is insignificant compared to the cost of owning and operating a building over its useful life. According to the Building Owners and Managers Association, only two percent of the total cost of building, owning and operating a typical office building over a 30 year period is for design fees and construction costs. Operations, maintenance, finance and employee costs account for the remaining 98 percent of the total costs.

Conclusion

Although some green building strategies can reduce the initial cost of a building, most of these strategies will cost slightly more than a conventional building. However, if these strategies are designed synergistically, the initial building cost can be minimized and significant savings can be realized over the life of a building.

You can expect the following economic benefits from a green building:

1. Reduced operating costs. It is possible to reduce building energy consumption by 20 to 30 percent within the constraints of most building budgets. This increased energy efficiency can reduce energy costs over the life of a building. Native landscaping can reduce landscape maintenance costs by $1,500 to $4,500 per acre per year as compared with conventional turf grass.

2. Reduced waste costs: Green buildings that are designed with raised computer floors and flexible open space can significantly reduce construction waste in facilities that undergo frequent remodeling. Reusing an existing building can also significantly reduce new material usage and cost compared to building a brand new building.

3. Reduced liability: Enhanced indoor air quality can reduce the risk of "sick building syndrome'' and the associated legal costs that may be incurred if the problem cannot be easily remedied.

4. Enhanced employee productivity: Several case studies of completed green buildings have shown significant improvements in productivity because workers were breathing better quality air, had a connection to the outdoors and worked in spaces with natural daylight.

5. Public relations: Since green building is relatively new, we have found that many green building projects have received local and national media coverage even before ground breaking.

6. Streamlined regulatory approvals: Sustainable site design strategies often can build public trust and streamline regulatory approvals.

7. Niche marketing opportunities: Several retailers who sell green products have built green stores and corporate headquarters in order to enhance the marketing of their green product lines. Some hospitality companies have used selected green building strategies to differentiate their services in the marketplace and to obtain a higher price for these services.

The key to realizing the economic benefits of green building is to work with design and construction professionals who have experience with this approach to construction. Since no two building projects are alike, these professionals can work with clients to develop focused green building strategies that are cost effective and respond to the unique needs of a client's business. The need for knowledgeable professionals is particularly acute given the explosive growth of new materials, technologies and services that have come about in the last few years.

References

1. United States Green Building Council (USGBC); Leadership in Energy & Environmental Design Reference Guide Version 2.0; August 2000; USGBC, Washington, D.C.; website: www.usgbc.org

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential; ASHRAE; Atlanta, Georgia; website: www.ashrae.org

3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); Standard 62 – Ventilation for Acceptable Indoor Air Quality; ASHRAE; Atlanta, Georgia; website: www.ashrae.org

4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); Standard 55 – Thermal Environmental Conditions for Human Occupancy; ASHRAE; Atlanta, Georgia; website: www.ashrae.org